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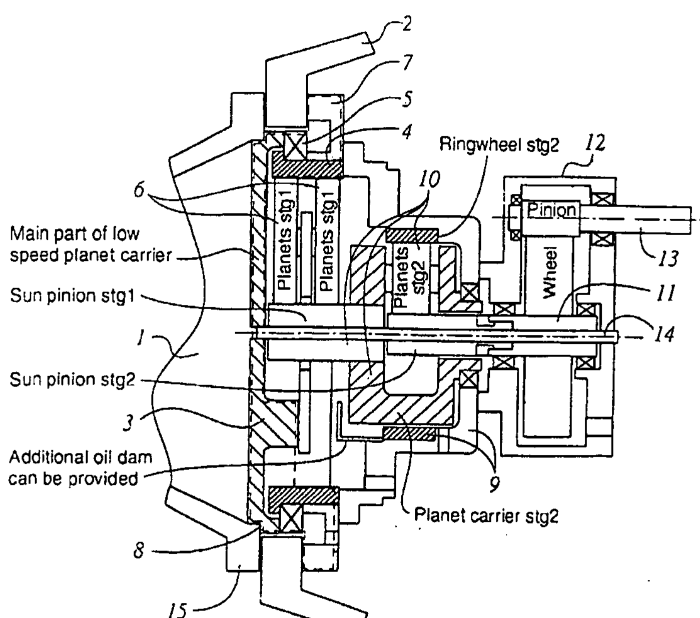
(54) Title: MODULAR WIND TURBINE DRIVE ARRANGEMENT



(57) **Abstract:** A gear unit for use in a wind turbine drive arrangement, the gear unit having an integrated rotor bearing arrangement and interfaces with the nacelle and rotor hub of the wind turbine, and the geometry of the gear unit and its interfaces with the nacelle and rotor hub being arranged to allow disassembly of the completely assembled gear unit from the nacelle and rotor hub at least primarily by axial movement in a direction away from the rotor hub.

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

MODULAR WIND TURBINE DRIVE ARRANGEMENT

The present invention relates to the drive train of a wind turbine - typically consisting of as shown in ure 1 rotor blades (100), a rotor shaft (110) supported by bearings (120), a gear unit (130), a generator (140) and couplings (150).

The drive train of a wind turbine is characterised by its situation high up in the nacelle (160) at the top of a 50 or 100 metre high tower. This makes the drive train difficult to reach or disassemble from the tower should this need occur and typically requires expensive crane equipment. Wind turbines are however often situated at remote locations that may be hard to reach with large cranes. Furthermore, the expanding off-shore market for wind turbines creates new challenges to handle this problem, as the water surrounding the turbine and the climate conditions at sea further complicate the access to the turbine nacelle.

When the need occurs to replace drive components in the nacelle, it is important that this can be done in the shortest time possible, not only because of general cost reasons, but also as the access time may be limited due to weather conditions that are sometimes hard to predict.

The above would typically call for drive train assemblies with clear interfaces between the different components and low functional integration, so as to allow removal of one component without the need to remove the others.

At the same time, wind turbine sizes have developed from rotor diameters smaller than 30 metre in the early eighties to rotor diameters larger

than 100 metre under development today, and with powers that have developed from 30 kW to several MegaWatts. This development is however characterised by the fact that the forces acting on the mechanical components of the turbine, for instance on the gear unit, grow more than proportional with the size and power of the turbine. Mere extrapolation of existing designs therefore leads to bulky, high weight drive trains.

From this evolution, the urge is created to integrate drive components so as to reduce size and weight of the overall drive train and nacelle. Some new concepts include for instance eliminating the rotor shaft and its bearing arrangement, replacing it with a large diameter bearing arrangement that may or may not be integrated with the gear unit.

Combining the above requirements, the problem addressed by the present invention is how to design an integrated drive arrangement that in the first place minimizes the need to disassemble it from the nacelle when a failure occurs by allowing service in the nacelle, and minimizes time and effort required to disassemble the gear unit from the nacelle should this be necessary.

The present invention provides a solution to the requirements mentioned above by means of an integrated gear unit design of a modular nature, and wherein either the gear unit as a whole or a number of the modules can be disengaged from the drive train assembly.

Further aspects of the invention will become apparent from the following description, given by way of example only, of an embodiment of the

invention given in conjuction with Figure 2 which shows a sectional view of a drive arrangement of the present invention.

All modules 6, 8, 9, 10, 11 and 12 are connected to each other in seriesand finally to the rotor hub 1 and nacelle 2 typically by means of bolts, pins and/or retaining rings as appropriate.

As can be seen from Figure 2, the geometry of the gear unit has been designed to allow axial disengagement from the nacelle and the rotor hub in the direction away from the rotor hub.

Figure 2 also shows several modules that can disengage in the axial direction away from the rotor hub 1. Depending on the available equipment for instance the capacity of an on-board crane in the nacelle, the modules can be disassembled one by one or in combinations. Because of the axial disassembly feature, equipment in the nature of a guiding rail or rod through the energy bore 14 (typically provided for supply of electrical energy to the rotor region and / or control of rotor blade pitch) could also be used.

To remove the last module 8, consisting of the ring gear 4, main bearing arrangement 5, main part of the planet carrier 3 and main connecting flange 7, the wind turbine arrangement in Figure 2 is provided with an engageable static holding connection 15 between nacelle 2 and rotor hub 1.

As can be seen from Figure 2, removing each consecutive module or combination of modules gives also service access to the next module(s), allowing in-nacelle replacement of the module or parts thereof and facilitating possibilities for close inspection and cleaning should this be required.

Special attention should be paid to the fact that in the embodiment of Figure 2 of the present invention, the planet carrier design 3, 6 of the low speed planetary cell allows the planets and their bearings to be disassembled and replaced without the need to disassemble the main part of the low speed planet carrier 3 from the rotor bearing arrangement 5, the rotor hub 1 or the nacelle 2. Connecting the engageable connection between rotor hub 1 and nacelle 2 may or may not be needed for this action.

The high speed shaft end 13 is typically connected to the generator by means of a seperate coupling. The generator (see Figure 1, not shown in Figure 2) may be either foot mounted on the nacelle or flange mounted to the gear unit. In the latter case, the complete drive train consisting of gear unit with integrated rotor bearing arrangement, coupling and generator can be axially disengaged as a whole from the nacelle.

CLAIMS

1. Gear unit with integrated rotor bearing arrangement for a wind turbine drive arrangement characterized by the fact that the geometry of the said gear unit and its interfaces with nacelle (2) and rotor hub (1) allow to disassemble the completely assembled gear unit from the nacelle and the rotor hub in a (primarily) axial movement in the direction away from the rotor hub.

2. Gear unit with integrated rotor bearing arrangement for a wind turbine drive arrangement provided with an engageable static holding connection (15) between nacelle and rotor hub, characterized by the fact that the geometry of the said gear unit and its interfaces with nacelle (2) and rotor hub (1) allow to disassemble the completely assembled gear unit from the nacelle and the rotor hub in a (primarily) axial movement in the direction away from the rotor hub.

3. Gear unit according to claim 1 or claim 2, characterized by the fact that the gear unit consists of a number of modules that can be disassembled either one by one or in various combinations from the nacelle and the rotor hub

4. Gear unit according to any one of claims 1 to 3, characterized by the fact that each of the said modules has a weight lower than half of the overall gear unit weight

5. Gear unit according to any one of claims 1 to 4, characterized by the fact that the said modules can be disassembled by means of an on-board crane in the nacelle.

6. Gear unit according to any one of claims 1 to 5, characterized by the fact that the said modules can be disassembled by substantially axial movement in the direction away from the rotor hub

7. Gear unit according to any of the preceding claims characterized by the fact that the planet carrier design of the low speed planetary cell allows the planets and their bearings (module (6)) to be disassembled and replaced without the need to disassemble the main part of the low speed planet carrier (3) from the integrated rotor bearing arrangement (5), the rotor hub (1) or the nacelle (2).

8. Gear unit according to any of the above claims characterized by the fact that the gear unit can be split in a high speed module (12) consisting of a gear stage with its bearings and casing assembly, an intermediate sun pinion (11), a module (9) containing the intermediate stage ring gear and casing assembly, a module (10) containing the intermediate planet carrier, planets, planet bearing assembly and the low speed sun pinion, a module (6) containing low speed planets, planet bearings and the removable part of the low speed planet carrier, and a module (8) containing the main flange (7) connecting the gear unit to the nacelle, the low speed stage ring gear (4) and the main part of the planet carrier (3) of the low speed stage.

9. Gear unit according to any of the above claims characterized by the fact that the generator that is connected to the high speed shaft end (17) is flange-mounted to the gear unit thus can be considered as an additional module of the assembly with the same possibilities as indicated in the above claims.

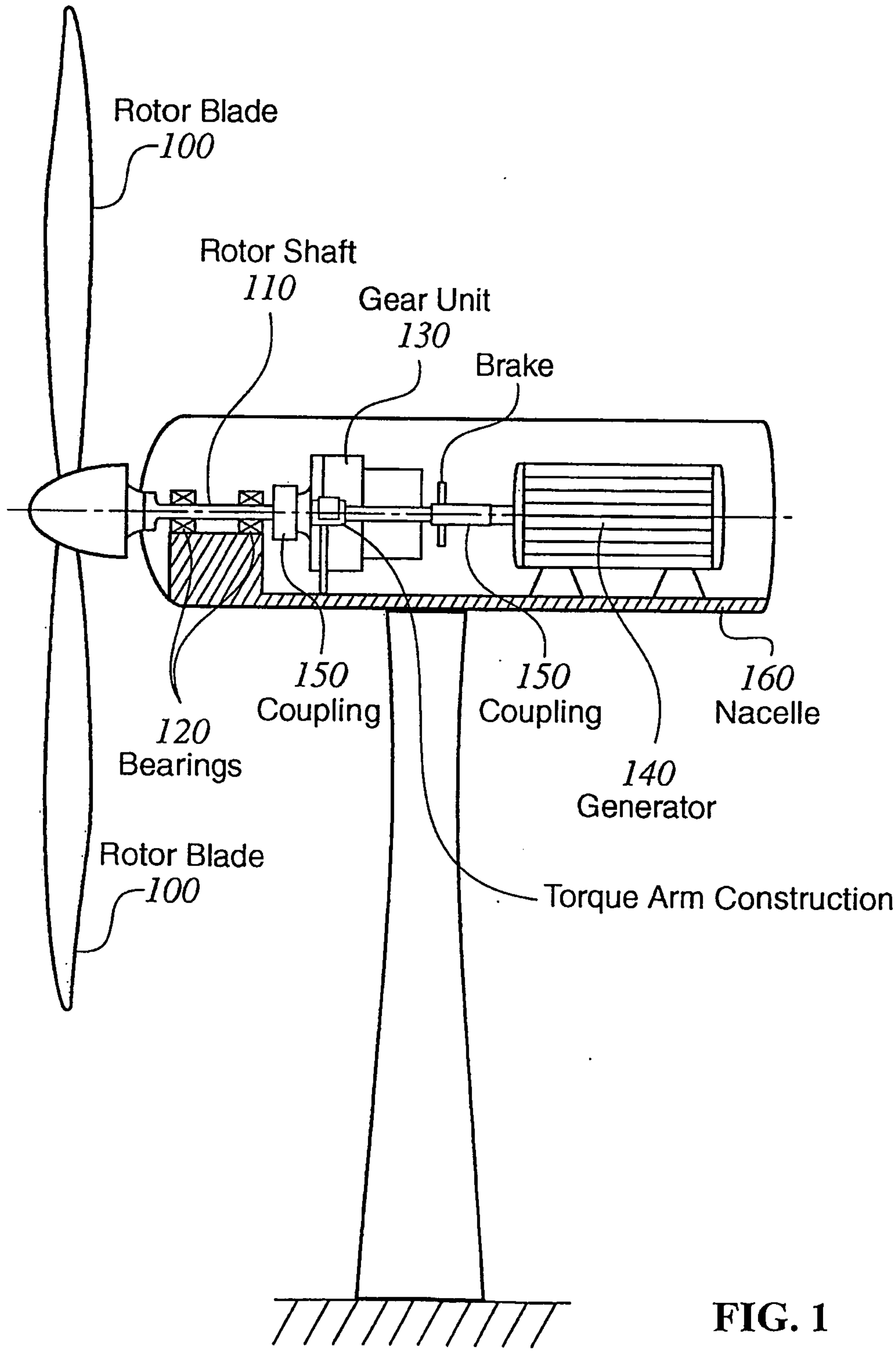
Rotor Blade
100
Rotor Shaft
110
Gear Unit
130
Brake
150
Coupling
150
Coupling
160
Nacelle
120
Bearings
140
Generator
Rotor Blade
100
Torque Arm Construction

FIG. 1

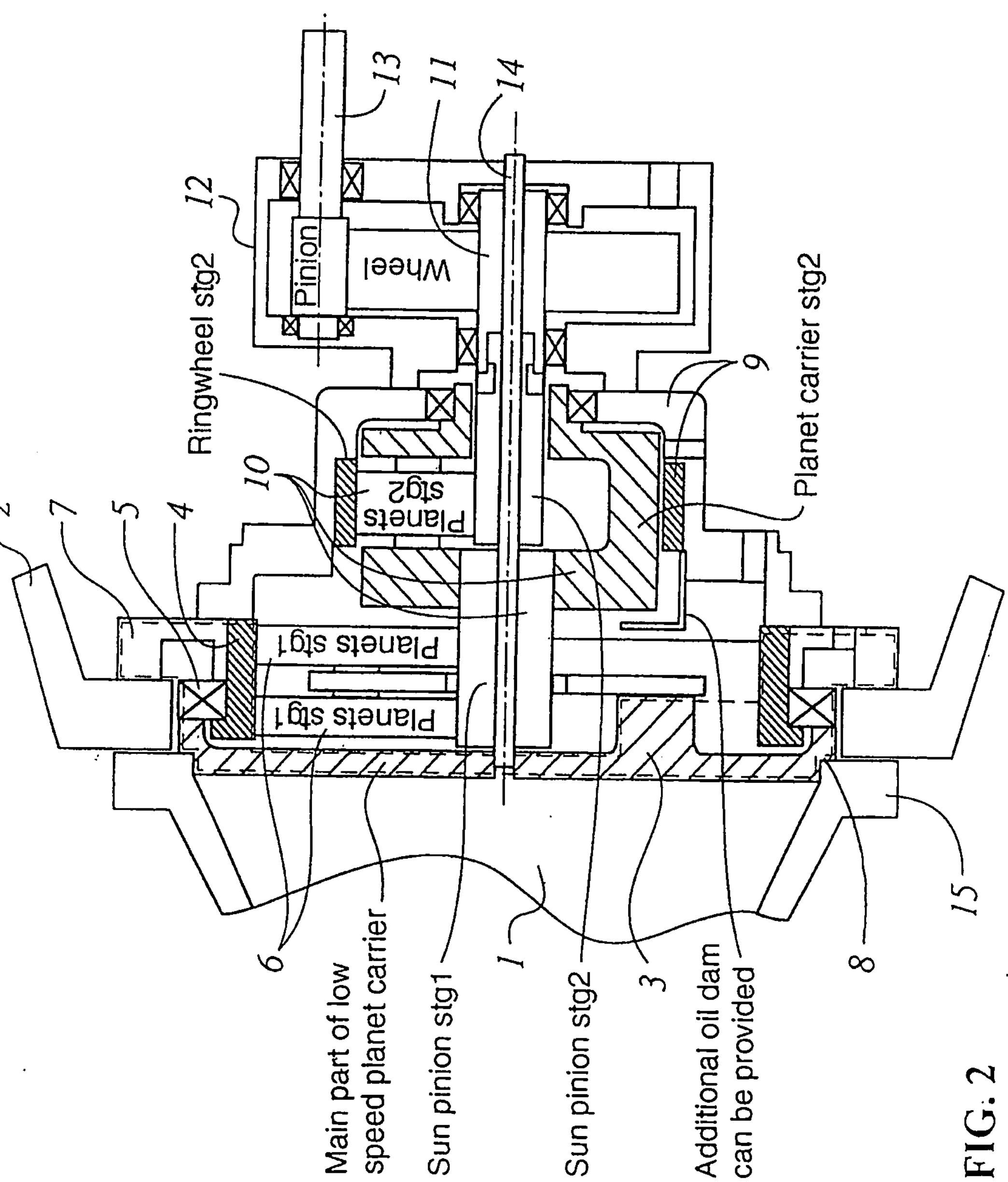
2
7
5
4
10
Ringwheel stg2
12
Pinion
Wheel
13
11
14
9
Planet carrier stg2
Planets stg2
Planets stg1
Planets stg1
6
Main part of low speed planet carrier
Sun pinion stg1
1
Sun pinion stg2
3
Additional oil dam can be provided
8
15

FIG. 2

FIG. 2 Contd.

KEY TO FIGURE 2

REFERENCE NO.	DESCRIPTION
1	Rotor hub.
2	Main frame of wind turbine.
3	Main part of low speed carrier.
4	Ring wheel stage 1.
5	Rotor bearing.
6	Module includes second part of low speed planet carrier, planets and planet bearings.
7	Main flange.
8	Module includes main flange (7), rotor bearing arrangement (5), low speed gear (4) and main part of low speed planet carrier (3).
9	Module includes ring gear and casing of intermediate stage.
10	Module includes planet carrier, planets and planet bearings of intermediate stage and sun pinion of low speed stage.
11	Sun pinion, intermediate stage.
12	Module includes gears, bearings and casing of high speed stage.
13	High speed shaft end.
14	Energy bore to feed energy from nacelle to rotor.
15	Normally not engaged.